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APPENDIX D

CHAPTER D6

CONTROL SYSTEM DESIGN GUIDELINES

D6.1 - GENERAL

The intent of this guideline is to establish uniform instrumentation and control (I&C) standards for materials, systems, and equipment for the City of San Diego Public Utilities Department (PUD).

This chapter deals with instrumentation and control systems for all wastewater treatment facility projects. Most of the guidelines also apply to pump stations and smaller facilities. For specific instrumentation and control system requirements for pump stations, see Section D6.8 of this guideline.

Instrumentation and control systems are to be provided to measure, control, and monitor wastewater and solids handling processes at each treatment facility. These processes will be monitored and controlled by field-situated instrumentation, control panels, and a distributed control system (DCS). In addition, other facilities such as off-site pump stations and pipeline monitoring stations, which have limited monitoring and control needs, will have either a programmable logic controller (PLC) based control system, or a DCS.

The DCS will serve as the primary means of performing process monitoring and control. In addition, certain plant support systems for example, closed circuit television (CCTV), fire alarm systems, maintenance management systems, laboratory information systems, energy management systems, management information systems, and process control training simulators will be integrated into the DCS to provide a shared and common interface to the operations staff.

The DCS at each treatment facility and the PLCs/DCS at other sites will support communications with the Central Operations Management Center (COMC), located at the Metropolitan Operations Center, which will have access to each facility's global database. Communications between each facility and COMC will be over a Wide Area Network which utilizes radio, telephone, fiber optic cable or any combination thereof. The entire system comprised of each facility's DCS, PLCs data communications and COMC is referred to as the Clean Water Operations and Management Network (COMNET).

DCS RESPONSIBILITIES FOR THE DESIGN CONSULTANT

The Design Consultant shall determine all system functional requirements, equipment layout and locations, and prepare design specifications and drawings for conduit, cable trays, primary power supply and other associated electrical and communications requirements for the DCS and field instrumentation. The Design Consultant shall review the existing control strategies provided by PUD and validate that any new or modified control strategy functions integrate seamlessly into the plant operations. PUD desires the same look and feel for the DCS programming across all projects. To facilitate this, the Design Consultant may be asked to attend additional coordination meetings such as a DCS/control strategy standardization meeting.

D6.2 - CONTRACTOR RESPONSIBILITIES

Table D6-1 shows the procurement, installation, and labor responsibilities of the Contractor. All field instrumentation devices and final control elements which are needed to support DCS functionality will be wired to new or existing process control modules (PCMs). Tables D6-2 and D6-3 define in greater detail the DCS and instrumentation responsibilities assigned to the Contractor.

CONDUIT AND WIRE

All conduits, including those for the DCS data highway, will be furnished and installed by the Contractor. All conductors, including power and grounding for the DCS equipment and field instrumentation will be furnished and installed by the Contractor. DCS grounding will use a special triad grounding system; specifications for this system are provided by the Design Consultant. All signal conductors, including DCS related fiber optic and coaxial cables, will be provided and installed by the Contractor. All wire termination will be performed by the Contractor.

Cables and conduits for non-DCS communications systems, such as SANNET, and the telephone system, will be furnished and installed by the Contractor.

Table D6-1

MATRIX OF CONTRACT RESPONSIBILITIES EQUIPMENT, DEVICES, AND MATERIALS

Products	Supply	Install
DCS Process Control Modules (PCMs)	Contractor	Contractor
DCS Workstations (WSs)	Contractor	Contractor
DCS Historian System (HS)	Contractor	Contractor
DCS PIN/FIN Hubs and network equipment	Contractor	Contractor
DCS Printers and Stands	Contractor	Contractor
Fiber Optic Network Cables (data highway cables)	Contractor	Contractor
Fiber Optic "DIN Cables"	Contractor	Contractor
All Other Communication Cables which Interconnect DCS Equipment	Contractor	Contractor
UPS Systems and Ancillaries for DCS equipment	Contractor	Contractor
Instrumentation Panels (including PLCs) and racks provided by Contractor	Contractor	Contractor
Panels (including PLCs) and racks provided by Contractor	Contractor	Contractor
Instrumentation provided by Contractor	Contractor	Contractor
Instrumentation provided as packaged equipment (including specialized communications cables required.)	Contractor	Contractor
Interposing relays to interface DCS control commands with equipment controls	Contractor	Contractor
DCS Isolated (Reference) Grounding Cables and Rods	Contractor	Contractor
Closed-Circuit Television (CCTV)	Contractor	Contractor
Page/Party Communications System	Contractor	Contractor
Security Card Access System	Contractor	Contractor
Control Room LCDs	Contractor	Contractor

TABLE D6-2
MATRIX OF CONTRACTOR RESPONSIBILITIES
WIRE, CONDUIT, AND TERMINATIONS

Description	Supply	Install	Terminate
Power conduits and wire to all Contractor furnished equipment and devices.	Contractor	Contractor	Contractor
Signal conduits from Contractor furnished instruments to vendor/package furnished equipment and devices.	Contractor	Contractor	Contractor
Signal wire/cable from Contractor furnished instruments to vendor/package furnished equipment and devices.	Contractor	Contractor	Contractor
All conduits associated with the DCS data highway, DIN, and other communication links.	Contractor	Contractor	---
DCS data highway fiber optic, unshielded twisted-pair and coaxial cables	Contractor	Contractor	Contractor
Any other communications cables from Contractor supplied equipment to the DCS	Contractor	Contractor	Contractor
All cable associated with the DIN	Contractor	Contractor	Contractor
All conduits associated with the fire alarm, CCTV, page party and security/card reader systems.	Contractor	Contractor	---
All signal wire/cable associated with the fire alarm, CCTV, page party, and security/card reader systems.	Contractor	Contractor	Contractor
All power wire/cable associated with the fire alarm, CCTV, page party and security/card reader systems	Contractor	Contractor	Contractor
Ground conduits and wire/cable from power panel to PCM or any other CSP furnished equipment.	Contractor	Contractor	Contractor

TABLE D6-3 MATRIX OF CONTRACT RESPONSIBILITIES TESTING AND SERVICES	
Task	CONTRACTOR
Prepare DCS hardware/installation submittals (PCM, WSs, HS, CM, UPS, etc).	X
Prepare DCS software submittal.	X
Provide SAMA functional diagrams	X
Prepare annotated software listings of all Contractor-furnished PLCs and other programmable equipment	X
Prepare instrument submittal	X
Calibrate instruments	X
Prepare Contractor panel submittals.	X
Prepare loop drawings to support the termination of all DCS I/O and the installation of all instruments.	X
Perform operational readiness test (ORT) of DCS.	X
Perform ORT test of Contractor panels.	X
Perform loop tests.	X
Participate in plant startup.	X
Provide DCS information to support Contractor development of loop drawings	X

D6.3 - GENERAL DESIGN CRITERIA

GENERAL

The instrumentation and control (I&C) devices specified will be industrial grade, with specific emphasis placed upon the device's applicability to wastewater and solids handling applications. As a minimum, all work and equipment will conform to the I&C Standards defined in Table D6-4. Design emphasis will be placed on safety, process control, reliability, maintainability and economics.

Field-situated instrumentation devices will be electronic. Pneumatic control devices for valve actuation will be used only on those loops that require either an extremely rapid response or a set position in response to a failure detection (i.e., fail open, fail closed), or in hazardous areas. Intrinsically safe devices may also be used to meet requirements for hazardous areas.

Individual equipment monitoring will be performed by monitoring status contacts. Out-of-range or abnormal conditions will be annunciated by both visual and audible alarms.

PCMs, instruments, and control panels, including, both panels provided by the Contractor and instrumentation panels provided by a vendor/package, will be designed to accommodate all known immediate loads. Future loads will be allocated to future PCMs and control panels.

The Design Consultant shall allocate all required space and resources needed to support the installation of immediate and future PCMs and control panels. In those instances where future requirements are associated with devices being monitored or controlled by a PCM or control panel which is servicing current requirements, these devices will be sized using both current and future control requirements. All instrument ranges will be scaled for the current process flow and will be in terms of the measured variables.

In addition to meeting present needs, all PCMs and control panels will have a spare capacity (i.e., I/O cards, memory, panel size, terminations, power supplies) of 20 percent to be allocated for unanticipated utilization. All control panels which are designed to accommodate future expansion will be provided with blank plates to cover cutouts made for future devices.

STANDARDS

Numerous standards are applicable to the various facets of I&C work. Table D6-4 lists major standards and recommended practices that design consultants should be familiar with and follow in the design of the I&C system.

USE OF PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

In facilities with a DCS, PLCs will be used primarily for two purposes: (1) micro-PLCs used strictly as relay replacements, and (2) PLCs provided as a part of a vendor's standard package system. Allen-Bradley PLCs are the PUD standard, and should be specified by the Design Consultant.

PLC Redundancy

PLCs are highly reliable, with MTBFs greater than 15 years. Unless the software is carefully designed, redundant PLC systems do not work well, and in many cases actually reduce the system reliability over a single PLC. It is also very difficult to configure a redundant data link to the DCS whose system is less than an Ovation level 3.3. Therefore, redundant PLCs will not be used by PUD. Any critical application which the designer believes requires a redundant system should use the DCS for control, without a PLC.

PLCs Used as Relay Replacements

For micro-PLCs used as relay replacements, the designer should balance the cost and maintenance requirements of standard electromechanical relays against the cost and spare parts requirements of PLCs. Generally, micro-PLCs are desirable only when the number of relays in a panel fall in the range of 10 to 150. In this application, micro-PLCs should have neither a local operator interface nor a data link connection to the DCS. The PUD standard for micro-PLCs is the Allen-Bradley SLC-500 series.

PLCs Provided as a Part of a Vendor's Standard Package System

Examples of PLCs provided as a part of a vendor's standard package system are: UV disinfection controls, RO filtration units, HVAC controls and generator controls. This application is distinguished by extensive use of packaged control software and a substantial number of I/O's which are of secondary interest and do not directly affect the major treatment processes (monitoring of lamp status in UV systems, for example). Many of these systems are provided standard with separate operator interfaces. Because of limited space and maintenance requirements, panel-mounted color LCD operator interfaces for these packaged control systems are preferred over desktop personal computers. For these systems, the DCS will be used for supervisory control and monitoring via a communications link.

All PLCs and local operator interface panels provided for a packaged system project will be of a common manufacturer. Furthermore, the Design Consultant will consult with PUD prior to the naming of acceptable PLC manufacturers.

PLC-to-DCS Communications Links

Configuring a PLC-to-DCS communications link involves a lot of coordination and effort to operate properly. Generally, a hard-wired set-up versus a data link set-up evaluation should be performed for those systems which use less than 50 I/O points to the DCS.

Where required, PLC-to-DCS communication links will be directly routed to the related PCM location. The packaged systems supplier and the Contractor will be responsible for providing a RS-232 communications link to a DCS PCM, including all modems (fiber optic or short-haul modems). Fiber optic cable links, using multimode cable, are preferred. The data protocol will be 16-bit MODBUS RTU, with the PLC operating in the slave mode. The PLC programmer will include a heartbeat bit to be exchanged between the PLC and the PCM, and the Design Consultant will include this bit in the MODBUS I/O list. For larger systems which use Allen-Bradley PLCs, a direct Ethernet interface is preferred, which uses Allen-Bradley DF1 protocol over Ethernet. Design Consultants must carefully select I/O points included in PLC-to-DCS communications. Points transmitted must support the control strategies, necessary alarms, or otherwise be useful to the operator. Simply specifying that all PLC points will be transmitted to the DCS is not acceptable. A list of specific I/O points must be included in the respective specification section providing the PLC or other electronic data link.

PLC Programming Software

All PLCs will be furnished with complete original Microsoft Windows-based programming software, license, user manuals and connection cables. Specialized PLC programming computers are undesirable.

RELIABILITY AND BACK-UP SYSTEMS

Reliability

The design of all instrumentation and control systems will be compatible with the reliability and redundancy criteria used to design process and electrical systems. For the purposes of this discussion, reliability will be defined as a measurement of the ability of a component or system to perform its designated function without failure.

Backup Control

Wastewater treatment and reclamation facilities must function continuously. The Design Consultant shall identify each critical process and I&C system that is required for the continuous operation of the wastewater system and develop an explicit plan for maintaining wastewater system operation in case of system malfunction. In most cases, manual control is acceptable. In other cases, failure of a control device will only affect a single process unit which in itself is redundant. In those cases when the process is too dynamic for manual control, or the failure of the device causes an unacceptable reduction in process capacity which cannot be compensated for by manual control, backup control systems will be provided.

Backup Automatic Control

Backup non-DCS automatic control typically uses hardwired relays, single-loop controllers or proprietary stand-alone controllers. Backup automatic control must be designed for automatic failover from DCS control. The Design Consultant must be aware that the use of backup automatic control creates very complex systems which typically require extensive additional DCS programming and additional I/O. Such systems are often less reliable than reliance on DCS control, with manual backup. Where backup automatic control is used, the design must provide for bumpless transfer of control from the DCS to/from the panel. **For these reasons, use of backup automatic control must be explicitly approved by the City.**

Critical Process Equipment

Critical process equipment, I/O cards, and instrumentation will be defined as those devices which, if failed, would:

- jeopardize operator safety,

- have the potential for eminent equipment damage or resulting overflow, spillage, line rupture, etc.,

- disable the functioning of the plant if corrective action is not taken within 30 minutes, or

- impact the safety of the general community.

For either backup manual or automatic control, all monitoring, annunciation, and interlocking functions for backup which are critical to maintaining process stability and plant safety, will be housed in instrument panels provided by the Contractor.

LEVEL OF AUTOMATION

The DCS will integrate the operation of all process equipment into a plant-wide control system by performing stop/start and modulating control functions. All process equipment systems will be provided with all requisite motor operated valves and position feedback devices to enable DCS re-valving and activation of a backup or standby device in the event of a failure of the lead device.

In addition to the provision of automated controls, all process equipment, including valve actuators, shall be operable from manual controls which are local to the equipment. Manual control stations will be provided and located to enable the safe and judicious operation of process equipment in the event that the DCS is unavailable. The use of local control panels (LCPs) shall be minimized. Each proposed use of an LCP must be approved in writing by PUD. The allocation and distribution of manual controls will be as follows:

1. Local control panels (LCPs) which are typically provided with equipment and whose deployment is approved by PUD, will be furnished by the vendor of the respective equipment. Manual control stations related to the vendor’s equipment will be located on the vendor LCP.

2. Manual control stations will be clustered near the vendor LCP or the equipment to enable the convenient manual control from a single location of any and all auxiliary equipment which is necessary to support the efficient operation of the vendor’s equipment. Typically, these manual control stations include valve actuator controls (e.g., Local/Remote switches; Open, Stop, Close push buttons; and indicating lights for full open and full closed positions) which are needed to route flows to/from specific units of process equipment or to select particular sources/destinations for process flows; and ancillary equipment manual controls (e.g., Local/Remote switches; Stop/Start push buttons; speed control rheostat and indication if equipment has variable speed capabilities; and Running light). The Design Consultant shall evaluate and define the contents of each manual control station and present recommendations to PUD for review and approval.

3. For those process equipment devices which are not traditionally provided with a vendor LCP, manual control stations for all equipment required to operate the related process will be clustered as described in preceding item 2.

4. It is acceptable to mount clustered manual control stations on uni-strut members.

5. All status and alarm information associated with process/process equipment/facility support equipment will be displayed local to the equipment and transmitted to the DCS. The use of a common alarm in lieu of specific alarms is not acceptable.

Table D6-4
I&C STANDARDS

Reference	Title
API RP550	Manual on Installation of Refinery Instruments and Control Systems
IEEE 100	Dictionary of Electrical and Electronic Terms
IEEE 472	Guide to Surge Withstand Capability (SWC) Tests
ISA S5.1	Instrumentation Symbols and Identification
ISA S5.3	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and computer Systems
ISA S5.4	Instrument Loop Diagrams
ISA RP7.3	Quality Standard for Instrument Air
ISA RP12.6	Installation of Intrinsically Safe Instrument Systems in Class I Hazardous Locations
ISA S18.1	Annunciator Sequences and Specifications
ISA S20	Specification Forms for Process Measurement and Control Instruments, Primary Element and Control Valves
ISA S51.1	Process Instrumentation Terminology
NEMA 250	Enclosures for Industrial Controls and Systems
NEMA ICS	Industrial Control
NFPA 70	National Electrical Code (NEC)
NFPA 72	National Fire Alarm Code
NFPA 820	Recommended Practice for Fire Protection in Wastewater Treatment Plants

FIELD INSTRUMENTATION

Before design, the Design Consultant should check with PUD Waste Water Treatment and Disposal for the current list of standard instruments. All field instruments will be the latest proven design manufactured. Each instrument will have a history of successful use in its specified application. For key process measurements, if the failure of any single field instrument could jeopardize the integrity of a dynamic process before operator action can be taken, redundant instruments in a fault tolerant configuration or triplicate instruments in a voting logic arrangement will be provided. In those instances where a field instrument is available in an intelligent version, the intelligent transmitter will be provided.

INSTRUMENT AIR

In those instances where pneumatic instrumentation devices are used, instrument air systems will be specified to produce an air quality which conforms to ISA RP7.3. A minimum of two air compressors will be provided. The compressors will be oversized to take into account the relatively short service life of the Teflon rings used in instrument compressor cylinders.

CONTROL PANELS

Control panels, which include both panels provided by the Contractor and panels provided by vendor/packages, will utilize enclosures which are environmentally suitable for the area they are to be installed in. All control panels which require NEMA 3 or 4 ratings will be provided with window kits to preserve the panel's integrity and enable operations ready access to information. Control panels in coastal areas such as the Point Loma Wastewater Treatment Plant shall be NEMA 4X stainless steel. Lens covers for indicating lights on all control panels will be colored as follows:

1. **Red-ON when:**

    a. Motor not running (STOPPED).

    b. Valve CLOSED (not fully opened).

    c. Device not energized.

    d. Circuit breaker OPENED.

2. **Green-ON when:**

    a. Motor running in forward direction (fast speed for multi-speed motors).

    b. Valve OPEN (not fully closed).

    c. Device energized.

    d. Circuit breaker CLOSED.

3. **White-ON when:**

    a. Power available.

    b. System in AUTOMATIC mode.

    c. Monitoring taking place.

4. **Amber-ON when:**

    a. Malfunction trip.

    b. Equipment locked out.

    c. Alarm condition.

GAS FIRE SUPPRESSION SYSTEMS

Because the DCS system is not functionally dependent upon the operation of any critical location, computer or control room, gas-type fire suppression systems such as FM-200 generally do not enhance system reliability sufficiently to compensate for their expense and hazard to personnel. These systems are also subject to increasing regulatory control and may be banned altogether in the near future. Therefore, FM-200 and similar fire suppression systems will not be used. Fire extinguishers suitable for this type of application will be acceptable.

POWER SUPPLIES

All instrumentation panels and DCS powered instrumentation will be powered by redundant direct current (DC) power supply systems configured in a fault tolerant manner (i.e., the failure or replacement of a power supply will have no affect on the devices being powered). DC power supplies will be designated main and standby and will operate in parallel. The capacity of each system will be power limited to permit signal circuits to be treated as Class 2 circuits in accordance with NFPA 70 Article 725. Main and standby DC power supplies will be electrically separated by a semiconducting, solid-state device which permits automatic transfer of load power upon failure of the main supply. Failure and subsequent transfer will be annunciated at the panel and at the DCS by a single alarm. Power to the DC power supplies will be from two separate 120 volt alternating current branch circuits; one circuit will be 120 volt AC and a second circuit will be AC power from an uninterruptible power supply (UPS).

All UPSs will be provided with adequate gel sealed non-gaseous batteries to provide a 30 minute ride-through for all immediate and future panel devices. In addition to meeting present and future needs, all UPSs will have a spare capacity of 20 percent to be allocated for unanticipated utilizations. Branch circuits will be from the same panel board. Annunciation systems will be fed by a DC power supply. Signal conductors will be run in separate raceways from the power conductors. Separation between power and signal conductors will conform to NEC requirements.

D6.4 - DCS COMPONENTS

The Design Consultant shall address in the design the allocation of space, power, ground, and HVAC requirements needed to accommodate all DCS related equipment.

A distributed control system (DCS), new or existing, will function as the facility control system. The DCS will consist of the following primary elements:

- Process Control Modules (PCMs) which contain all of the control logic required to monitor and control its associated process. All PCMs are hardwired to field instrumentation devices with individual pairs of conductors or communication cables. All PCMs will be provided with redundant controllers and power supplies which are configured in a fault tolerant manner. PCMs will communicate digitally with PLCs, smart transmitters and other systems such as two-wire valve networks and fire protection systems. PCMs located near ocean environments shall be housed in NEMA 4X enclosures, air conditioned, and purged for protection against corrosive gases. A separate power circuit shall be provided for enclosure air conditioning. Internal enclosure temperatures, UPS status, and purging (where used) shall be monitored. New PCMs should be provided by Emerson to match existing equipment.

- Workstations (WSs) which serve as the operation's staff "window" into the process. WSs will be high performance personal computers which enable the plant staff to monitor, interrogate, manipulate, and document plant processes. New workstations should be provided by Emerson to match existing equipment.

- Environmentally Hardened Workstations (EHWSs) will be provided in outdoor areas with potential exposure to corrosive gases such as H2S, or located near ocean environments. Typically, EHWSs are located on filter gallery decks to permit visual inspection of filter status during manually controlled backwash cycles. Each EHWS shall be housed in NEMA 4X enclosures suitable for their intended application. A typical vendor of EHWSs is Daisy Data.

CONTROL ROOMS AND COMPUTER ROOM

- WSs and printers will be located in area control rooms (ACRs) and in the Operations Control Room (OCR). Major facilities, such as treatment plants will have an OCR and one or more ACRs. Smaller facilities, such as major pumping plants, will have only an OCR.

- At major facilities, the OCR will contain an operations control room console which houses WSs, and printers. The console will provide a centralized location at which the entire plant can be monitored and controlled. The CONSOLE will consist of a minimum of three WSs to be used to oversee plant operations. Each WS will also have the capability to serve as an engineering station used to perform system configuration and graphic generation functions. At smaller facilities, modular furniture provided by the Contractor will be used for desktop WS and printers.

- Each OCR at a major facility (not pumping stations) will have a large-screen flat-panel type LCD monitor system, with three or more panels, for display of process graphics and alarms. Each WS will have a separate video card dedicated to a flat-panel LCD monitor.

- Typically, each ACR will have one WS and one printer which will be housed in modular furniture. The WSs located in the ACRs will normally function as operator stations only. The Design Consultant should design the ACR layout to incorporate a modular office furniture installation, and include provisions for power and communications jacks. Additional space should be left for monitors and computer systems provided by others.

- The OCR and computer room will be located where the plant administrative/operation staff functions are performed. The OCR will integrate process control and facility administration functions by housing workstations, printers and all support system interfaces. The computer room will house historian systems, network communication equipment, plant-to-plant communication devices, off-site (telemetry) communication devices, and file servers to support the interfaces with support systems.

- The computer room will be designed to provide sufficient space for the UPS, network hubs, and fiber optic patch panels. For security purposes, telephone systems and computer network equipment for use on SANNET should not be located in the computer room. The Design Consultant should consult with the PUD before sizing this room.

- The computer room will be provided with a backup HVAC system.

- At major facilities, each OCR will have an adjacent conference room.

COMMUNICATIONS WIRING

- Each OCR and ACR will be provided with RJ-45 data jacks for the DCS data highway, and a conduit system linking to a central hub in each building in a “star” configuration. The DCS data highway is based on Fast Ethernet. The DCS data highway connections between building hubs will be multi-mode fiber optic cable. The DCS data highway connections between a building hub and the network nodes (PCMs and WSs) will be EIA/TIA Category 5e/6 unshielded twisted pair cable installed in conduit.

- At each location where termination of fiber optic cable is required, fiber optic patch panels with sufficient space to terminate all fibers including spares will be provided. Fiber optic jumpers, sufficient for all cross-connections, will be provided with the patch panels. All PCM conduits shall be sealed at both ends.

- The single-mode fiber optic cable used for the DIN is generally installed along pipelines The Design Consultant shall use the latest version guideline specification section 16780, Fiber Optic Cables Along Pipelines as the basis for design.

- Each office, OCR, and ACR will also be provided with RF-45 data jacks and a conduit system linking to a central hub in each building, separate from the COMNET DCS data highway hub, for the City's wide-area network and the facility LAN, generally referred to as SANNET. In major facilities, a separate computer room for facility SANNET servers and hubs will be provided. The Design Consultant shall consult with PUD to determine SANNET requirements.

- Uninterruptible power supplies (UPS) will be provided to provide a minimum of 30 minutes of clean regulated standby power to all DCS devices. At unattended pump stations, additional UPS power backup will be required.

PROCESS CONTROL MODULES (PCMs)

All process control modules (PCMs) will have processors configured in a fault tolerant manner. PCMs will be located in MCC rooms and will not be located in OCRs or ACRs. All PCMs will be designed to require front and rear access.

The number of hard I/O points that can be accommodated for each PCM depends on the overall complexity of the PCM control strategies and other factors. The typical range is 1500 points for an Ovation PCM with few outputs and little control logic. For older WDPF II PCM's the typical range is 500 I/O points. Before allocating PCM installation area and I/O requirements, the Design Consultant shall consult with PUD for the type of PCM to be used and the maximum I/O points allowed per PCM.

The Designer must plan carefully to avoid problems with physical I/O wiring restraints. Logical assignment of PCMs to individual or groups of process areas is another factor that must be taken into consideration.

Two sources of supply are required for the PCM power supply. One source is routed to the UPS and one directly to the PCM. If the PCM requires a dedicated refrigeration unit, a separate power feed from a power panel will be provided by the Design Consultant.

The Design Consultant shall use the following PCM data for design purposes:

- PCM size: three cabinets, each H =80"; W =24"; D =24". Total Width = 72"
- PCM power demand: 1.5 KVA
- PCM weight: 1200 LBS (3 cabinets)
- PCM ground requirement: a dedicated ground of 1 ohm maximum resistivity measured at the PCM through a maximum of 50 feet of #4 grounding cable.
- Heat generated by a WDPF II PCM (HVAC burden): 3000 btu/hr
- Heat generated by an Ovation PCM (HVAC burden): 1200 btu/hr
- PCM Access: Both front and rear cabinet access. I/O may enter cabinet from either top or bottom of the enclosure. PCMs shall be installed on concrete housekeeping pads.

UNINTERRUPTIBLE POWER SUPPLIES (UPSs)

UPS devices will be provided to service all DCS devices. The UPS devices will be located close to the devices they power. A UPS will be provided for each PCM area, ACR, OCR, and computer room and shall be designed to supply 30 minutes of backup power at rated output. All UPS devices will utilize sealed batteries that preclude the possibility of any gas discharge. The UPS will be provided with a static bypass transfer switch to provide primary AC power to equipment for UPS maintenance or in the case of UPS failure. The Design Consultant shall use the following UPS size, weight and input power requirements for design purposes:

KVA=1.5 to 6 KVA

1. Electronics: W =24"; D =32"; H =32"; Weight =250 lbs
2. Battery Rack: W =24'; D =32"; H =32"; Weight =500 lbs
3. Input Power: 120 volt AC, single-phase

KVA =6.1 KVA to 20 KVA

1. Electronics: W =24"; D =32"; H =32"; Weight =250 lbs
2. Battery Rack: W =24"; D =32"; H =32"; Weight =500 lbs
3. Input Power: 208 VACS

WORKSTATIONS (WSs)

WSs and printers will be provided at the OCR and at each ACR. The Design Consultant shall provide a raised floor for the OCR. The Design Consultant shall use the following WS size requirements for design purposes:

1. WS Size: W = 7"; D = 18"; H =16"
2. WS Monitor: 20" (W) x 20" (H) x 19" (D)
3. WS Weight: 86 lbs
4. WS Power Demand: 0.5 KVA

HISTORIAN SYSTEM (HS)

The HS will be located in a computer room adjacent to the operations control room. The Design Consultant will provide a raised floor for the computer room. The Design Consultant will use the following size requirements for design purposes:

1. HS Size: W = 32"; D = 18"; H = 16"
2. HS Monitor: 20" (W) x 20" (H) x 19" (D)
3. HS Weight: 86 lbs
4. HS Power Demand: 2.5 KVA
5. HS Ground Requirement: No special requirements.

ON-SITE FACILITY DATA HIGHWAY NETWORK COMMUNICATION SYSTEM

The DCS will utilize dual redundant fiber optic communication networks to interconnect all PCMs, WSs, and the HS. The Design Consultant shall provide two 4-inch diameter conduits for the DCS data highway. In order to minimize the possibility of both DCS communication network cables from being damaged by the same localized occurrence, each DCS communication network conduit, where possible, will be separated from each other by a minimum of 10 feet. Each major area of the plant will have a redundant communications hub. Each area communications hub is linked to a central redundant communications hub. All new network communications equipment should be provided by Emerson.

D6.5 - SIGNAL LEVELS AND LOOP POWER

All analog signals will be routed in dedicated conduits. All signals will conform to requirements associated with the DCS. All process signals will conform to the following:

1. **Analog Inputs-Conventional Two Wire and Intelligent Transmitters**

    a. Signal level to DCS will be 4-20 mA.

b. Signal will be an isolated input to the DCS.

c. All instrumentation shields will be terminated at the PCM, unless field powered, then the shield shall be terminated at the instrument and left floating, cut and coiled at the DCS.

d. For those field instruments associated with control panels (vendor panels or Contractor panels), signal power supplies will be located at the control panel. For those field instruments which are wired directly to a PCM, signal power will be provided by the PCM. All power supplies will be configured in a redundant fault tolerant manner in which (1) the failure of a power supply is annunciated, (2) the backup power supply assumes an on-line role automatically via diode auctioneering, and (3) the failed power supply can be replaced without having to disable the on-line power supply or any other system functions.

e. Intelligent transmitters will be provided with a HART communications protocol. The protocol provided will be upgradeable to the requirements of SP 50. The 4-20 mA signal, loop power, and digitized signal will use the same twisted pair of shielded conductors. In order to preserve loop integrity and loop response times, each intelligent transmitter will have a dedicated pair of shielded twisted wire linking the transmitter to the DCS.

f. Two-wire valve control and monitoring systems will be used where there are sufficient numbers of valves to provide an economy of scale - typically, 15 or more valves. Requirements for two-wire valve control and monitoring systems will be included in the valve operator mechanical specifications, and in the I/O points lists. Two-wire valve control and monitoring systems will be configured for the following data and control points:

1. Open Valve Command
2. Closed Valve Command
3. Valve Opened - Status
4. Valve Closed - Status
5. Valve in Remote - Status
6. Valve in Thermal Overload - Alarm
7. Valve Torque (Analog) - Measured Value
8. Valve Field Control Unit Failure –Alarm

Valves that require analog control (modulating) should not be placed on the two-wire valve control system due to the slow network response time.

g. Intelligent process instrumentation shall be directly connected to the DCS through a bi-directional digital communication interface at the PCM. Analog transmission of variables from intelligent transmitters is not acceptable.

2. **Analog Inputs-Four Wire Transmitters**

   a. Signal level to DCS will be 4-20 mA.
   b. Signal will be an isolated input to the DCS.
   c. Signal power supply will be located at transmitter.
   d. The DCS will have a fixed load limitation of 250 Ohms. Zener diodes will be installed at the control panel (vendor panel or instrumentation panel) terminal strip to ensure loop integrity.

3. **Analog Outputs**

   a. Signal level from the DCS will be 4-20 mA at 24 VDC.
   b. Signal will be an isolated output from the DCS.
   c. Signal power supply will be located at the PCM.
   d. Signal will have a load impedance requirement of 600 Ohms.

4. **Digital Inputs**

   a. Loop will be powered by 24-volt power supplies in the PCM.
   b. Field device will be an isolated “dry” contact rated for 1 amp at 24 volts DC.
   c. Field contacts for alarms will be wired to digital inputs in a "fail-safe mode” (i.e. an open wire or contact will result in an alarm).

5. **Digital Outputs**

   a. Digital outputs will be unpowered, isolated contacts from interposing relays in the DCS rated at 10 amps, 120 volt AC. Each output will be individually fused.
   b. 120 volt AC power for all digital outputs will be provided from the PCM UPS.
   c. Separate conduits will be provided for 24 volt control circuits and 120 volt circuits.

D6.6 - INSTRUMENTATION EQUIPMENT

GENERAL

This section describes equipment to be used for instrumentation, control, operator interface, data communication, voice communication, and security. PUD has established standard instrument vendors. The Design Consultant shall base their design on these vendors.

INSTRUMENTATION APPLICATIONS

Table D6-5 lists recommended instruments for specific applications. The first instrument of each type listed, indicates the strongest preference by PUD. The information in this table shall be used as a guide to preferred instrumentation. Table D6-6 summarizes optional methods of making common measurements.

1. **Diaphragm Level Transmitter:** The diaphragm level transmitter is one of the simplest and most reliable level transmitters available, but the diaphragm elevation must be below the lowest level to be measured. These transmitters, used with a stilling well, are preferred for wastewater pump station wet wells. Where the vessel is not at atmospheric pressure, a compensation connection to the low pressure port available on these transmitters shall be provided. A typical manufacturer is SMAR.

2. **Ultrasonic Level Transmitter**: Ultrasonic level transmitters have proven reliable, where sufficient clearance exists between the maximum liquid level and the transmitter, and where the container geometry permits. A typical supplier is Milltronics.

3. **Bubbler**: Bubbler systems are not preferred. Bubbler systems will be used only for applications where a suitable mounting position for a diaphragm level transmitter or ultrasonic transmitter is not available, or where design considerations preclude the use of other, preferred devices. Bubbler systems require a reliable source of instrument quality air. A constant flow purge rotameter will be used with all bubblers. Stainless steel piping (minimum Schedule 40) will be used due to its strength and resistance to corrosion. Bubblers will not be used in anaerobic digesters or pump station wetwells.

4. **Float and Displacer Level Switches**: Float switches are suitable for high level alarms. In general, displacer switches will be used where the level element is normally submerged. Be sure that the float or displacer element is guided in all but the most quiescent vessels. An external chamber will be used for pressure vessels such as hydro-pneumatic tanks to permit maintenance without venting the tank. Drexelbrook is a typical supplier of liquid level probes.

5. **Radio Frequency/Admittance Level Switches**: Radio frequency/admittance level switches are inexpensive and can be used for both vented and pressurized vessels. The probe is in contact with the fluid, so use with greasy fluids will be avoided.

6. **Pipeline Liquid Level Monitor**: A pipeline liquid level monitor on the suction of each positive displacement pump will be provided.

7. **Diaphragm Pressure Transmitter**: Diaphragm pressure transmitters are the most common instrument used in industrial plants. They are economical and provide accurate measurement with long-term stability. Diaphragm pressure transmitters are available in gage pressure, differential pressure, and absolute pressure versions. This type pressure transmitter will be used in preference to motion-balance types for all pressure measurements. A typical supplier is SMAR.

8. **Piston-Diaphragm Pressure Switches**: This type switch contains a diaphragm actuated precision switch. The diaphragm is protected from over-strain by the switch body. Accordingly, these switches can be over-ranged without affecting calibration. The diaphragms and other wetted parts are available in many exotic materials eliminating the need for chemical seals. Gage pressure ranges from 2.5 inches WC to 4,000 psi are available. Differential pressure and compound range types are also available. These switches should be used in lieu of Bourdon tube and bellows type switches. Mechanically latched switches will be avoided; the mechanical latch is the first item to fail in a pressure switch. Electrical lock-up circuits will be used instead.

9. **Pressure Gauges**: Solid-front glycerin filled units will be used for corrosion protection and limited surge protection. Bourdon tube elements are preferred for most ranges. Diaphragm or bellows elements may be required for low ranges.

Table D6-5 INSTRUMENTATION APPLICATION	
Application	Preferred Instrument Type
Raw wastewater wet well level	d/p cell, ultrasonic
Influent flow	Parshall flume, if open channel; or magnetic flow meter on pump discharge
Bar screen differential level	Sonic
Headworks flood level	Float switch
Primary sludge flow	Magnetic flow meter on discharge of pumps
Primary scum hopper level	d/p cell
Grit aeration air flow	Thermal dispersion, pitot tube, orifice
Aeration blower flow	Thermal dispersion, venturi, pitot tube on suction with RTD for temperature compensation and diaphragm pressure transmitter for pressure compensation
Aeration air header pressure	Diaphragm pressure transmitter
Aeration dissolved oxygen concentration	Dissolved oxygen probe
Aeration tank pass air flow	Thermal dispersion, venturi
Return activated sludge flow	Magnetic flow meter on discharge of pumps
Waste activated sludge flow	Magnetic flow meter on discharge of each pump
Low digester gas pressure	Diaphragm pressure transmitter on header
Digester gas flow	Thermal dispersion flow transmitter on each digester
Chlorine residual	Chlorine residual analyzer
Sludge blending tank level	Diaphragm or sonic level transmitter
Digester feed sludge flow	Magnetic flow meter on feed pump discharge header
Digested sludge flow	Magnetic flow meter on feed pump discharge header
Chlorine inventory	Strain gage weigh scale on trunnions or rail unloading stations as applicable
Chemical feed	Magnetic flow meter on the discharge of each pump
Chemical level	d/p cell
Dewatered sludge flow	Conveyor type strain gage weigh scale or strain gage truck scale as applicable
Progressive cavity pump	Annular ring pressure sensor on discharge with

Table D6-5 INSTRUMENTATION APPLICATION	
Application	Preferred Instrument Type
protection	switch to trip pump on high discharge pressure; pipeline liquid level monitor on suction to trip pump on dry suction. All trip logic and required timers will be hardwired.
Centrifugal pump protection	Pressure switches on the suction and discharge with hardwired timer and control to trip pump upon detection of low suction pressure. If applicable, low flow switches can be used. For pumps in self-cleaning wet wells, provide a local manual bypass of the low suction pressure trip on the pump control panel.

Table D6-6

MEASUREMENT METHODS

Variable	Type	Fluid	Device
Level	Analog	All	Diaphragm level transmitter, sonic, Microwave
	Digital	Clean	Sonic, Float or Displacer
		Dirty	Sonic, radio frequency/admittance, Bubbler
Pressure	Analog	All	Diaphragm pressure transmitter
	Digital	All	Piston diaphragm
Temperature	Analog	All	RTD < 300 degrees F
			T/C > 300 degrees F
Flow	Analog	Clean liquids	Rotameter < 1 inch Magnetic <12 inch Propeller > 12 inchVee-notch or Cipolletti weir
		Dirty	Magnetic _ 24 inch
		liquids	Time of flight ultrasonic > 24"
			Parshall flume
		Sludge	Magnetic all sizes
		Gas	Thermal dispersion, venturi
		Air	Rotameter or bypass rotameter
	Digital	Dirty	Doppler liquids
		Clean liquids	Vane or Piston
Weight	Analog or digital	N/A	Strain Gage

10. **Diaphragm Seals and Annular Rings:** Diaphragm seals or annular rings will be used to keep corrosive chemicals or solids out of pressure instruments. However, these instruments do present installation and maintenance problems. Corrosion-resistant materials in the pressure instrument will be specified in preference to diaphragm seals whenever possible. Diaphragm pressure transmitters that do not have pressure elements that can collect solids will be specified. Standard chemical seals introduce significant hysteresis error into pressure measurements. Their use will be avoided on pressure measurements that are less than 20 pounds per square inch gage (psig). These instruments will not be used on vacuum applications.

Be aware that the displacement capability of diaphragm seals and annular rings is limited. A piston-diaphragm type pressure switch and a Bourdon tube type pressure gauge can be connected to a single seal, but bellows type instruments require large displacements and the seal cannot support two such instruments. Dow Corning DC200 silicone oil will be used as the fill fluid for general applications. For chlorine or other strong oxidants, Dow Chemical FS5 Fluorlube will be used.

a. **Diaphragm Seals:** Diaphragm seals will be used for protection of pressure instruments from corrosion. For protection from solids on large pipelines, weldelet type pipe connections and diaphragm seals will be used to eliminate plugging piping connections between the main pipeline and the seal. DO NOT use diaphragm seals for sludge applications - use annular rings.

b. **Annular Rings:** Annular rings will be used to keep solids out of the instrument. Annular rings are not available for corrosive fluid applications. On large pipelines their cost becomes prohibitive. PUD staff will be consulted in the deployment of annular rings.

11. **RTD Temperature Sensor:** The 100 ohm platinum RTD will be used in most temperature measurements in wastewater facilities. The stability and accuracy is superior to other measuring devices. However, this unit can be damaged by vibration. Ten ohm copper RTDs will be used in large motor windings and thermocouples will be considered for all ranges in vibration applications. Two-wire RTD transmitters are available where the RTD is a great distance from the nearest instrument panel, but the RTD will be wired directly to the instrument panel where the distance is less than 200 feet. Thermowells will be used for all piped applications. Thermowells will be avoided for gas applications unless the line cannot be easily depressurized for RTD maintenance. SMAR is a typical supplier for temperature transmitters.

12. **Thermocouple:** Thermocouples (T/C) will be used for all applications in which operating temperature is greater than 300 degrees Fahrenheit. Typical T/C applications in wastewater treatment plants are engine exhaust and incinerators. Choose the T/C type and extension wire type based on the specific application. Two-wire transmitters will be provided and the lengths of T/C extension wire will be minimized. Thermowells will be used for all liquid applications and will be 316 stainless steel. Thermowells will be avoided for gas applications unless the line cannot be easily depressurized for T/C maintenance.

13 **Temperature Switches:** Temperature switches with a vapor-pressure element will be used. The long-term stability of this type of unit is better than bi-metal units, but bi-metal units may be necessary in small vessels because of element size.

14. **Temperature Gages:** The preferred temperature gage is a pressure gage with a vapor-pressure type temperature element. The long-term stability is better than bi-metal units, but bi-metal units may be necessary in small vessels because of element size. Mercury or glass stem type thermometers will be avoided because broken gages create a hazardous material clean-up problem.

15. **Rotameters:** Common rotameter applications in wastewater facilities are chemical feed, purge and chlorine/sulfur dioxide gas flow. Purge rotameters are practically site-flow gages. An appropriate low-cost glass-tube unit will be selected for purge applications. PVC units with magnetic coupling between the float and the indicator or transmitter mechanism will be used for chlorine and sulfur dioxide gas applications. Rotameters may be installed in a bypass configuration to measure larger flows than practical with direct measurement. A standard orifice plate installation will be provided with the orifice sized to produce 50 inches WC drop, and connect the rotameter to the differential pressure taps on the orifice flanges. A typical supplier is Brooks Instruments. For clean service, UFM is a typical supplier.

16. **Propeller Meters:** Propeller meters are very low cost devices suitable primarily for service water flow measurement. Long-term accuracy is questionable. For transmitting applications, two-wire transmitting heads are available. The Sparling "magnetic worm" type eliminates gearing in the propeller head and is therefore more durable than other types. McCrometer utilizes a "speedometer cable" drive that also eliminates gearing in the propeller head. Units with propeller head gearing, which adds friction and decreases life expectancy, will be avoided. Propeller meters will be used for clean, cool water where accuracy is not critical.

17. **Magnetic Flow Meters:** Magnetic flow meters are cost-effective for clean-water and dirty-water service in moderate sizes and mandatory sludge service regardless of size. Pulsed direct current excitation will be specified for all but pulsing flows where alternating current excitation must be used. Ceramic liners will be specified for meters up to and including 6-inch size. Polyurethane liners will be specified for meters larger than 6-inch diameter except for sludge service. Teflon liners will be specified for sludge service meters larger than 6-inch diameter. A minimum flowing velocity of 5 feet per second will be maintained on primary sludge service and 3 feet per second on secondary sludge service. Flowing velocities over 10 feet per second will be avoided where grit is present. Magnetic flow tubes will always be installed with a Dresser coupling or Victaulic flexible-style coupling on at least one end to remove longitudinal stress on the tube and facilitate removal for service. Flow tubes will be installed with a bypass manifold arranged to permit access to the electrodes for cleaning without removing the tube from the pipeline. Where the tube is mounted in a vertical pipeline, the flow direction will be upward. Magnetic flow tubes require 5 diameters of straight pipe run upstream and two diameters of straight pipe downstream. Use wafer style bodies for tubes 6-inches in diameter and smaller. Lifting beam, eye bolts or something to facilitate handling will be provided for all full body meters; they are heavy and fragile. A typical supplier is Krohne America.

18. **Time-of-Flight (TOF) Ultrasonic Flow Meters:** TOF sonic flow meters are very cost-effective for large pipe runs; however, extreme care is required in their application. Gas bubbles must not be present at the point of measurement because they are opaque to sonic waves. Gas bubbles formed by low pressure zones within pumps will prevent satisfactory operation, and these bubbles may not reabsorb into the fluid for 300 to 600 feet following a pump. Bubbles also form in septic wastewater and after free falls. Straight

approach will be at least 10 diameters upstream and 2 diameters downstream from the meter. A typical supplier is Nusonics.

19. **Weirs:** Weirs are a simple way to measure clean water flows over a very wide range and with good accuracy. An ultrasonic or microwave level transmitter will be used upstream of the weir for level measurement. Be sure that the downstream hydraulics are designed so that the weir is never submerged. The water passing over the weir must not adhere to the weir plate. Be sure that upstream approach conditions provide uniform flow approaching the weir. A typical supplier of an ultrasonic flow meter for this application is Milltronics.

20. **Flumes:** Flumes provide a simple method of measuring dirty water flows in open channels. Parshall flumes will be used in rectangular channels and Palmer-Bowlus flumes will be used in round channels. The Parshall flume provides a particularly wide measurement range. Flumes are not particularly accurate, and must be carefully constructed with good approach conditions. A straight length of channel will be provided upstream of the flume for at least 10 times the throat width. The design of the downstream hydraulics must provide the flow over the terminus of the flume will achieve critical depth. The Design Consultant should consider including straightening vanes to increase flume accuracy. Where flumes are used, levels will be measured by a sonic level transmitter. A typical supplier of open channel flowmeters is Marsh-McBirney.

21. **Thermal Dispersion Flow/Low-Loss Venturi Meters:** Thermal dispersion flow meters or low-loss venturi meters will be used for air flow and digester gas flow. These meters accurately measure mass flow over a wide range of flow velocities with minimal headloss. The flow element will be installed through a hot-tap assembly to facilitate flow element cleaning without isolating the pipe line. A dirt/moisture separator will be provided upstream of the flow element. Straight approach must be at least 10 diameters upstream and 10 diameters downstream from the flow element. Typical supplier is FCI.

22. **Doppler Ultrasonic Flow Switches:** The flow switch version of Doppler flow meters will be used for detecting the presence of solids bearing fluid flow. The flow profile must be fully developed and there must be no swirl if these units are to produce an accurate measurement. Vibrations present in typical pumps interfere with proper operation. Adequate installation requirements cannot be met in most wastewater facilities. A typical suppler is Polysonic.

23. **Vane and Piston Flow Switches:** Clean water flow switches are most commonly used to detect purge and cooling water flows. The service is not demanding, but verify that the selected switch type can handle the required velocity. A typical suppler of vane flow switches is WE Anderson.

24. **Weighing Systems:** Strain gage based weigh systems will be used rather than hydraulic systems. The vendors listed below each have their strong points. BLH has a load cell that is more resistant than most to lateral forces. Use this cell in any application where lateral forces are difficult to completely eliminate. Eagle Microsystems builds chlorine scales complete with trunnions for ton cylinders. Ramsey Engineering specializes in silos.

Weighing systems are a combined structural/instrumentation problem. Consult with the scale builder to get recommendations on the number of load cells required and on methods of controlling lateral forces.

25. **Analytical Systems:** Many analytical variables are similar to common industrial measurements, and standard industrial instruments will be used. Other measurements present problems that are unique to the wastewater industry and special instruments will be used.

    a. **Standard Measurements:** Standard measurements include conductivity, oxidation reduction potential (ORP), turbidity, and pH. Industrial type two-wire transmitters will be used for these measurements. Typical suppliers include Rosemount for pH.

    b. **Dissolved Oxygen:** Dissolved oxygen is a common aeration tank measurement that has become very difficult with the advent of lower aeration rates and fine-bubble diffusers. Fluid velocity past the dissolved oxygen probe must be at least 1 fps to avoid depression of the reading in the vicinity of the probe. Biological growths on the probe must be avoided to prevent excessive maintenance. Do not use mechanical agitators which can be fouled by filamentous growths. Typical suppliers include Rosemount.

    c. **Chlorine Residual:** Systems will be specified with a pumped sample, bypass filter, amperometric technology, and automatic back-flush. Typical suppliers include Wallace and Tiernan.

    d. **Sludge Density:** Density measurement devices have not consistently provided accurate field measurements on fluids with suspended solids below about 2 percent. Above 2 percent solids, nuclear type devices have proven to be accurate; however are high maintenance items requiring frequent certification because of the radioactive material used. There have also been reports of safety problems with the devices. For these reasons, nuclear type density measurement devices will not be used. Ultrasonic type meters may be used, but are not consistently accurate and should, therefore, be used for sludge pump control only and not for absolute measurement of density.

26. **Combustible Gas Detection Systems:** Combustible gas detectors will be provided in accordance with NFPA 820. Analyze each area for the types of gases which may be present (heavier-than-air gases or lighter-than-air gases) and locate detectors appropriately. For example, in screen rooms, combustible gas detectors should be installed at both the ceiling and floor levels because both heavier-than-air combustible gases (like gasoline vapors) and lighter-than-air combustible gases (like methane) may be present. Specify combustible gas detectors with silicon/H2S poisoning-resistant cells. Combustible gas will be treated as a critical alarm (refer to previous section on Alarm Systems). The alarm will be connected to the nearest annunciator for local indication and interface to the DCS. A typical supplier of gas detection systems is MSA.

27. **Toxic Gas Detection Systems:** Appropriate toxic gas detectors will be provided in chlorine and sulfur dioxide handling areas. Alarm beacons will be provided at entrances to such areas and relay the alarm to the nearest annunciator for indication and interface to the DCS.

CONTROL EQUIPMENT

The primary control system will consist of PCMs and WSs installed at each individual facility. Vendor controls shall be minimal and will emphasize the use of PLCs and environmentally-hardened membrane panels in lieu of hardwired relays and conventional annunciators. All vendor PLCs will be of the same manufacturer and will have a digital communication interface with the DCS.

1. **Control Panels:** The primary use of local control panels is to provide emergency manual backup unit process operation in case of a dual-PCM failure. Only devices required for emergency backup use and for providing switchover to DCS mode shall be provided on local control panels.

2. **Digital Control Stations:** Digital control stations may be located either at the controlled equipment or in the process unit control panel. The choice will depend on the type of unit. Typically, control stations for complex systems such as large pumps, belt filter presses, and centrifuges should be in a control panel. Conversely, control stations for equipment such as clarifier drives, air compressors, sump pumps, and utility water pumps should be at the equipment.

   Each control station will, as a minimum, provide a means to manually operate a piece of equipment in case of dual-PCM failure. If the equipment is normally controlled by a PCM, the control station will include a MANUAL/PCM selector switch. This selector switch will include a contact that is closed in the PCM position to inform the PCM that this equipment is available for PCM control.

3. **Work Stations:** WSs will be compatible with other DCS hardware and connected to the facility DCS data highway at strategic points selected by the Design Consultant such as plant control room, laboratory, maintenance office and major unit processes. Each WS will act as a window into the COMNET system through which the operator can monitor and control the all processes. The PC-based workstations (PCWS) will be located in areas which require occasional and/or view-only access to DCS information, such as equipment maintenance offices and laboratories. The Design Consultant shall indicate on the plan drawings the location and provide DCS data highway access for PC workstations.

4. **Laboratory Information and Maintenance Systems Interfaces:** For facilities which include a laboratory, an interface with the Enterprise Daily Operator Report System (EDORS) will be provided.

5. **HVAC Interface:** Building HVAC systems shall be controlled by vendor-supplied building controllers. These controllers shall monitor and control and the various parameters required to control the building environment. A data link to a PCM shall provide the DCS the ability to monitor and control fans and compressors only. Monitoring and control from the DCS of the building environment, and monitoring of such parameters as temperatures, damper positioning, filter status and heating/cooling water valve controls are not desired.

6. **Energy Monitoring:** Power system monitoring systems, such as Multilin, where provided, shall be interfaced to the DCS via a MODBUS serial data link to a PCM. The DCS shall monitor only the following parameters: volts (average), amps (average), kilowatts, kilowatts (demand), kilowatt-hours and reactive load (VARS).

VOICE COMMUNICATION SYSTEMS

Voice communication around electronic control systems using walkie-talkies is hazardous to the control system. A standard 5 watt walkie-talkie creates a radio field of up to 100 volts per meter. Electronic control systems generally cannot withstand more than 20 volts per meter. Wired communication systems will be provided for use by WWTD personnel when in the vicinity of control equipment. A Page-Party system with telephone stations located conveniently throughout the facility will be provided. In general, an operator should not have to travel over 200 feet to a telephone station. Telephone stations will be placed in all locations where operators will tend to spend significant amounts of time. Jack stations will be provided at control panels, motor control centers, and work stations. Additional jack stations will be provided such that no instrument is over 40 feet from a jack station. Interconnect the phone system with the Page-Party system to permit jack-station hand sets to access the paging circuit and talk on one-party line.

SECURITY AND ACCESS CONTROL SYSTEMS

Every facility will be provided with a proximity card access system compatible with PUD's existing system. Outside doors used for primary access shall be provided with proximity switches, one outside card reader, electric latches, and key locks for emergency use. Each access control unit can accommodate approximately 8 doors, and shall be located in a secure area. Major facilities, such as treatment plants, will have a PC-based local server located in the computer room, connected to the card access master server (host computer) at MOC using a leased voice-grade line, fiber optic cable, or via SANNET. Unstaffed facilities shall provide a remote alarm through the COMNET DCS or PLC. Small facilities that do not have a local PC server will communicate directly to the master server at MOC via a leased dial-up voice-grade line. Do not use bypass schemes or local audible signals. The Design Consultant shall consult with PUD to determine the method of communication to the master server at MOC. In general, perimeter switches will be provided on all doors and windows. Where a building with many windows must be protected, use passive infrared motion detectors instead of putting perimeter switches on windows. This is not a likely situation in wastewater facilities.

CLOSED-CIRCUIT TELEVISION MONITORING SYSTEMS

Each facility will be provided with a CCTV monitoring system compatible with PUD's existing system. Closed circuit television will be provided to monitor entry gates to treatment plants, and also to provide extensive surveillance of the interior and exterior of each building for personnel safety purposes. Areas of special risk such as galleries and dry wells shall be monitored. Communications to CCTV cameras will use fiber optic cables. In most cases, cameras will be monochrome, with remote pan/tilt/zoom used where cost-effective. A CCTV control console will be integrated into the OCR main control console in larger facilities. CCTV will not be used to monitor equipment status. The Design Consultant shall consult with PUD to determine camera placement, and equipment requirements. CCTV video will be integrated into the DCS at larger facilities.

FIRE ALARM SYSTEMS

The Design Consultant shall design and provide complete fire alarm systems in unattended facilities and in accordance with NFPA 820 in attended facilities. Fire alarm systems will comply with NFPA 72A and 72E. Ionization smoke detectors will be used in accordance with NFPA 72E except in areas where hazard is primarily a substance likely to produce smoke particles larger than 1 micron where photoelectric detectors should be used. For large open spaces, photoelectric projected beam detectors will be used rather than a large number of point detectors. Audible fire and trouble alarms, and visual alarms, will be provided in accordance with NFPA 72A. Ventilation system characteristics will be taken into account when determining the number of detectors required and in selecting detector locations. Where ventilation systems are used to reduce classification of hazardous spaces, the ventilation system will be supervised by the fire alarm system as required by NFPA 820. Fire alarm systems will communicate status and alarm data to the PCM via RS-232 serial data communications using the MODBUS RTU protocol, with the alarm system operating as a MODBUS slave. PUD will be consulted prior to the selection of the interface with the DCS. The DCS will be provided with fire alarm graphic displays.

The Design Consultant shall provide alarm status monitoring of trouble, smoke detection, and sprinkler flow to the DCS for 24-hour remote monitoring at COMC.

D6.7 - DESIGN PROCEDURES AND STANDARDS

CONTRACT DRAWINGS

The Design Consultant shall prepare P&IDs, panel faceplate and schematics, DCS communication network conduit and device location drawings for all equipment including fire alarm system, CCTV, paging, security and communications systems and all instrument installation drawings which are in conformance with the requirements of the guidelines. These drawings will be presented in a hardcopy and electronic MicroStation format for archiving purposes.

INSTRUMENT AND INPUT/OUTPUT LISTS

The Design Consultant shall compile a listing of all of the required I/O associated with the DCS. A separate list will show all process instrumentation. The lists will meet the following:

- The I/O points list will indicate all points required to meet immediate and future process, with future points indicated.
- An I/O summary will show the total points of each type, by PCM or PLC.
- The I/O points list will indicate I/O which must be separated from other I/O in order to preserve inner-process integrity.
- Spare points will not be annotated.
- This data will be provided in a hardcopy and electronic spreadsheet (Microsoft Excel) format. The instrument and I/O lists should be a permanent maintenance document.
- The Design Consultant shall maintain the I/O and instrument lists and issue regular updates. The Design Consultant shall update the I/O and instrument lists to as-built conditions.
- DCS alarm activation and annunciation shall adhere to a priority hierarchy that is established and maintained at the DCS system. Each alarm shall have an associated alarm priority level defined as:

    1. Level 3 - Life Threatening or Danger Conditions.
    2. Level 2 - Critical process alarms that shall create a plant shutdown condition, cause a critical process failure or severely hinder plant operation.
    3. Level 1 - Minor process alarms associated with warning conditions and minor equipment failures.

4. Level 0 - Informational alarms shall not hinder operation or cause equipment failure.
5. Analog points shall have two alarm priorities, one for high alarms and the second for low alarms.

- The I/O list will be organized by PCM/PLC and will include the following information:

1. Tag number of I/O point
2. Associated loop number
3. Description of I/O point
4. Alarm priority (for alarm points)
5. Scale of the analog process variable
6. Set value displayed for a digital point
7. Rest value displayed for a digital point
8. P&ID drawing number on which the I/O point is indicated
9. I/O type (analog, digital, input, output, etc.)
10. Data link name or number, if applicable
11. Associated PCM or PLC number
12. Fail safe "yes" or "no" (for alarm points)
13. Any applicable remarks or comments not covered elsewhere
14. I/O totals summarized at the end of the list

PANEL FRONT VIEW DRAWINGS

Front view drawings showing control devices are required for control panels. Each face-mounted device will show with a reference number which is coordinated with the instrument and input/output summary. Front view drawings will show maximum cabinet dimensions, but cannot be fully dimensioned in detail because specific device dimensions and clearances are not generally known during design. Nameplate and annunciator schedules will be provided on the drawings.

INSTRUMENT SUMMARIES

The Design Consultant shall compile a listing of all required Contractor provided instruments. The instrument summaries will list each instrument and panel's tag and loop number, specification number, and associated instrument panel name/number. I/O list (including tag and loop number, process description, and P&ID drawing reference), panel drawing reference number, installation detail number, instrument range, instrument setpoints, trip points, NEMA rating, material requirements, and all other data needed to precisely define the instrument requirements. This data will be presented in a hardcopy and electronic Microsoft Word or Excel format.

The Instrument Summary list will be organized by instrument type and will include the following information, where applicable, for each type of instrument:

1. Instrument tag number
2. Instrument Type
3. P&ID drawing number on which the I/O point is indicated
4. Associated specification section
5. Applicable installation detail
6. Instrument Service
7. Hazardous area requirements.
8. Size
9. Range
10. Process Connection
11. NEMA Rating
12. Seals Required
13. Mounting
14. Mechanical drawing on which the instrument is indicated
15. Electrical drawing on which the instrument is indicated
16. ISA Data Sheet reference
17. Any applicable remarks or comments not covered elsewhere

INSTRUMENT SPECIFICATIONS

The Design Consultant shall compile instrument specifications which detail the technical requirements of each type of field and panel mounted instrument to be provided. This data will be presented in a hardcopy and electronic Microsoft Word format. The Design Consultant shall use the instrumentation specifications, where provided as a basis for developing the design, and develop specifications for all items which are not covered by the current guidelines.

MECHANICAL, ELECTRICAL AND HVAC SPECIFICATIONS

The Design Consultant shall incorporate the dry contacts and analog I/O required for the DCS interface into the design specifications for each item of equipment. During the submittal review phase, the Design Consultant shall check each submittal to be sure that the specified dry contacts and analog I/O are being provided, and will not approve "or equal" substitutions that do not provide the required I/O interfaces.

DATA SHEETS

The Design Consultant shall require the Contractor to prepare and submit data sheets conforming to ISA S20 for the specific equipment used.

LOOP DIAGRAMS

The Design Consultant shall require the Contractor to prepare and submit loop diagrams conforming to ISA 5.4 and Section 13300 of the Guideline Specifications to verify the DCS interfaces with all instrumentation and devices being provided or installed under the project. The loop diagrams will also define all interfaces with equipment provided by vendors. The Design Consultant shall make the Contractor aware of the PUD CADD standards and loop drawing standards that are posted on the City of San Diego's web site. The following three-sheet format is required:

1. **Sheet 1:** A device schedule developed from an electronic spreadsheet or database file, which will be submitted with the loop diagrams. The table will show the following.

   a. Device tag number, with Prefix, Unit Process, ISA Tag Prefix, Tag No. (a four-digit number based on the loop number) and Tag suffix, when required
   b. Equipment Service description
   c. Device Type
   d. Location
   e. Device Manufacturer
   f. Model No.
   g. Spec. No.
   h. Area Contractor (if applicable
   i. Submittal No.
   j. Calibrated Range/Remarks
   k. Data Sheet No.
   l. I/O Signal type (AI, AO, DI, or DO)
   m. Signal Level
   n. Device Range (full available instrument range)
   o. Engineering Units
   p. Process Set Point
   q. Loop Diagram No., reflecting the field instrument tag number.
   r. Loop Drawing File Name
   s. Interconnect Drawing File Name
   t. P&ID drawing number

2. **Sheet 2**: Provide loop drawing meeting the Requirements of ANSI/ISA S5.4, except that intermediate terminal junction boxes may be omitted and be shown on Sheet 3 for clarity. Butt splices and wire nuts shall be shown on as-builts, with the corresponding termination housing (JB, LB, etc. shown on Sheet 3.

3. **Sheet 3**: Provide point-to-point conduit and wiring diagrams, showing instrument, wire and cable numbers, intermediate terminal junction boxes, and PCM terminations. Wire identification numbers will reflect the field instrument tag number, and not the DCS I/O number.

DCS INPUT/OUTPUT TAG NUMBERS

DCS I/O tag numbers will generally reflect the device tag number. Each I/O tag number will be unique. The tag prefix will be based on ISA-5.4, with the following additional special acronyms:

Acronym	Signal Use
YL	Ready Signals/ Motor Run
ZL	In Computer/Remote Status
ZSO	Device Open
ZSC	Device Closed
YA	Device Trip/Alarm
HS	DCS Start/Stop Switch
JI	Kilowatts
JQI	Kilowatt hours
JXI	KVARs
JFI	Power Factor

WIRING DIAGRAMS

The Design Consultant shall require the Contractor and its instrumentation contractor/panel builder to prepare and furnish panel wiring diagrams as O&M information. Wiring diagrams will conform to NEMA ICS1-101A.2.5.

RISER DIAGRAMS

Riser diagrams will be prepared for fire alarm system, page party systems, CCTV, security systems and telephone systems. Riser diagrams will be supplement by specifications and equipment location drawings.

PROCESS AND CONTROL STRATEGIES

The Design Consultant shall prepare a control strategy for each instrument loop that interfaces with the DCS or PLC. In addition, the Design Consultant shall also develop process control strategies which interlock numerous individual control strategies to provide an efficient operator interface. Control and process strategies shall list all applicable inputs and outputs, provide a general description of what the strategy is supposed to do, and provide an explicit description of how each element in the control loop functions. Each strategy will describe monitoring, alarm, and control functions associated with both local (Hand, Off and Local Auto) and DCS (DCS Manual and DCS Automatic) control.

Each strategy will describe in detail the sequence of operations required to start or stop a device under normal and abnormal conditions. All process trip points, set points, and timers will be quantified in each strategy. Strategies will be annotated using the instrument and equipment tag numbers shown on the P&IDs, and a P&ID reference shall be included. Each strategy will contain the required functionality needed to support DCS process graphic screens used to monitor and control the related control strategy. Each strategy will also describe what should happen under abnormal conditions such as DCS failure, transmitter failure, unreasonable process values, and loss of communication between PCMs or PLCs which have information which effects the operation of the strategy. The control strategy will also define requirements for graphical indications to the operator for when a control strategy is ready to be started up and indications for permissives that are preventing the strategy from starting up. This data will be presented in a hardcopy and electronic Microsoft Word format.

The following standard format shall be used:

Preface to Control Strategies Section

1. Tag numbering scheme.
2. Definitions and Terms.
3. Controls and control functions provided for all equipment, unless otherwise noted.
4. Local control station at equipment
5. Local/DCS switch
6. Alarms logic - open contact for alarms (fail-safe).

Format for Each Strategy

Required Sections are listed in **Bold and Underline**. If there are no functions under those sections, indicate “none” under the heading. The examples shown are only for the purpose showing the level of detail required. Examples are available.

General Description

1. Provide an overview of the strategy. The following are example items.

    a. *There are three variable speed digester feed pumps*.

b. *The pumps transfer blended biosolids from the blend tanks to three digesters.*
c. *The pumps can be automatically controlled by the DCS.*
d. *The pumps can be controlled manually by the operator via the DCS.*

2. Reference related documents such as IO lists and P&IDs. Examples:

   a. *P&IDs for this strategy are: 73-I-60, 73-I-70*
   b. *The I/O listing for this strategy is located in Appendix B.*

Related Equipment

1) List Related equipment items and equipment numbers.

References

1. List P & I D's for this strategy.

2. List other associated Strategies or Loop Descriptions

Overview of Strategy

Provide general description, including operator actions, DCS monitoring, DCS historical data recording requirements, interface between control from local control panel and from DCS. The following is an example:

1. Influent pumps normally operate automatically under DCS control. Pump sequence and speed are a function of the influent wet well's level. As the level of the wet well increases, the pump's speed will increase and additional pumps will be brought on line. All pumps will be running at the same speed. As the level in the wet well decreases, the pump's speed will also decrease, and pumps will be taken off line.

2. Flow will not be allowed to exceed the MAXIMUM FLOW operator set point. In the event that the equalization basins are full, then the flow from the wet well will be limited to the PRIMARY EFFLUENT operator set point. Once primary effluent flow limiting is initiated, the operator will be required to reset the system to resume normal level control.

3. Manual backup pump START/STOP and SPEED controls are provided in the Influent Pump Station control room. Emergency stop push-buttons are provided in the vicinity of the pumps.

4. The wet well level will be measured through the use of redundant bubbler systems. Each of the levels will be trended at the DCS.

<u>Local Control</u>

Provide description of control and monitoring functions available on local control panel(s):

1. Describe hard-wired interlocks.

2. Provide description of hierarchical control interface between LCP functions and higher level (DCS) functions. Control should be hierarchical, which means that simultaneous parallel control capability from both an LCP and the DCS is inhibited. An exception is an "Emergency OFF" pushbutton switch on the LCP or at the equipment.

3. For example, describe the function of any Local/DCS switches on local control stations and LCPs.

4. If Local/DCS switches are not provided, describe how the DCS knows when it can control, and describe how operator at LCP knows when the DCS is in control.

5. Describe bumpless transfer functions when control is switched from LCP to DCS, and from DCS to LCP. Check I/O list to make sure that DCS is monitoring all inputs required for bumpless transfer.

<u>DCS Control</u>

1. **<u>DCS Manual Control</u>**

   a. List and describe control and monitoring functions available from DCS. Items in *italics* below are examples. A more detailed example is available.

   b. List specific inputs and outputs for each strategy by I/O tag.

   c. Examples:

      i. *"AUTO/MANUAL selection of the lead/lag pump is provided.*

      ii. *In the MANUAL LEAD/LAG mode, the LEAD and LAG pumps shall be selected manually in any desired order."*

2. **<u>DCS Automatic Control</u>**

   a) List and describe DCS automatic control functions

   b) List variables and signals received from other Loops and describe the Loop function: *Receive HEADWORKS FLOW signal from Loop 01F551. HEADWORKS FLOW shall not exceed MAXIMUM FLOW set point.*

c) List all tunable constants in control loop.

d) Describe operator selections available and describe the effect on the controls:

i. *Automatic pump sequencing and speed control of the influent pumps use the level controller's output signal. Control of the pumps includes sequencing and speed control calculations, pump availability checks, pump START/STOP interlocks and alarms as described below.*

e) Describe all software interlocks. A detailed example is available.

<u>Failure Modes</u>

1. Limit settings: describe automatic control when limits are reached.

2. Describe automatic and operator manual control actions on device failure.

<u>Software interlocks</u>.

1. Describe all software interlocks to be implemented in the strategy.

2. Define whether interlocks apply to DCS Automatic Mode, DCS Manual Mode or both.

<u>Restart After Power Failure strategy.</u>

1. This is ordinarily a separate control strategy.

2. Describe sequence of automatic restart. Sequence must take into account equipment and process requirements and electrical load.

3. Describe actions on equipment failure during automatic restart.

4. Describe any modified start-up sequence required for limited power (operations using in-plant power generation only).

<u>Phased Shutdown on Power Failure</u>

1. Describe sequence and setpoints for phased shutdown of equipment on partial power failure, anticipation of power cutbacks, or limited power availability.

<u>Out of Service</u>

1. Description of devices which determine in/out of service status for each piece of equipment. In-service (IS)/out-of-service (OOS) algorithms mask or block out all or

selected alarms associated with the OOS device i.e., if a wetwell is declared OOS, low level alarms shall be inhibited.

2. Additionally, if a device has been designated OSS, all control routines declare the equipment as being unavailable for service.

Setpoints and Alarms

1. Provide initial alarm and process setpoints for each AO (analog output) associated with this strategy, or provide reference to I/O list for setpoints.

2. Provide the following alarm setpoints for analog inputs: High, High-High, Low, Low-Low.

3. Provide alarm priorities in the I/O list.

4. Provide Rate of Change setpoints (if used).

Communications Interfaces

1. Provide description of any digital interfaces to instruments or equipment such as fire alarm systems, HVAC, power circuit monitoring, variable-frequency motor drives (VFD's), etc.

MECHANICAL LAYOUT DRAWINGS

Each field instrument that has a connection to process equipment or piping will be shown on the mechanical layout drawings, as well as all instrument panels. Pneumatic tubing runs are ordinarily installed by pipe fitters and will be included on mechanical layout drawings.

ELECTRICAL LAYOUT DRAWINGS

Each field instrument that has electrical connections, and all instrument panels, will be shown on electrical layout and schematic drawings, with all instrument tag numbers. Particular care will be given to ensure that adequate space is reserved for instrument panels. Electrical signal cables and raceways are installed by electricians and will show on electrical layout drawings, including data links.

WIRING TAG NUMBERS

The Design Consultant shall use the following scheme in developing all design documents, including specifications, circuit and raceway schedules and drawings. The specifications shall require the Contractor and Subcontractors to follow the identification scheme in submittals and in field wiring. The Electrical specification shall also include cable numbering for all power conductors based on the following scheme.

Power, control and signal cables shall be assigned an identifier which shall be based on the facility or area number, the name of the primary process device (field instrument) and the loop number to which the circuit is connected or serves, a suffix to indicate circuit type, and an appendage which identified individual wire number and polarity at each termination point.

CABLE/WIRE NUMBERING

- The first group consists of the two characters denoting the facility or area number, as defined in the program guidelines.
- The second group of characters identifies the device being served (field device, not DCS I/O tag). For instrumentation and controls, this will be the ISA tag number. Other devices should conform to the nomenclature used in the related contract documents (i.e. mechanical or electrical equipment number).
- The third group consists of the four digit loop number or equipment number.
- The fourth group uses one of the four suffixes shown in the table below. Where multiple circuits of the same type are routed to the same endpoint, the suffix will be -1, -2, or -3, as required.
- At each device or termination point, the circuit identification number is appended with the individual wire number. For Direct-Current (DC) circuits, wire polarity is shown in parentheses as (+) or (-).
- Spaces are not allowed, and letters are not case-sensitive, and written in upper case.

SUFFIX	CIRCUIT TYPE	EXAMPLE
(A)	24 v dc analog (4-20 mA)	01FIT022(A)-1(+)
(C)	120 volt AC control	05P320(C)-2
(D)	24v dc digital status or control	55LSH201(D)-1(+)
(P)	Power (120 volt, 480 v, 5 kv, 15 kv, etc.)	01MCC6101(P)-2

CALCULATIONS

Show all data, assumptions, and equations that are used in calculations. Define all symbols. Cite references for data and for equations other than simple things like Ohms Law or converting gallons/minute to cubic feet/second. Identify any computer programs with revision date used. Instrumentation calculations, as a minimum, will include the following:

1. Control valve sizing
2. Flow meter sizing
3. Paging loudspeaker power requirement
4. Fire alarm smoke detector spacing
5. UPS sizing for non-DCS equipment

D6.8 - PUMP STATION CONTROL SYSTEM DESIGN GUIDELINES

A Pump Station Contractor (PSC) is similar to the previously discussed facility Contractor. The design of instrumentation and control systems for PSCs will follow the guidelines for facility Contractors already presented in this Chapter. The purpose of this section is to clarify and highlight some of those guidelines as they apply specifically to pump stations.

The processes at pump stations will be monitored and controlled by field-situated instrumentation, control panels, and either a distributed control system (DCS) process control module (PCM) or a PLC. Other PUD facilities, such as treatment facilities and pipeline monitoring stations, will be linked to the pump stations over the COMNET communication network.

WASTEWATER COLLECTION DIVISION
SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

The Wastewater Collection Division operates a number of smaller pump stations and the Mission Bay Sewer Interceptor System. These are monitored and controlled by a SCADA system which uses spread-spectrum radios for communications between the remote facilities and the master station at MOC II. Although this system shares a central control room (COMC) at MOC II with the COMC monitoring and control of the treatment facilities and large pumping stations, it is a separate system. Design guidelines for this system and for the remote facilities’ instrumentation and controls are available from the Wastewater Collection Division.

PSC’s RESPONSIBILITIES

Tables D6-1, D6-2, and D6-3, along with the associated text, summarize the responsibilities assigned to a PSC, with the responsibilities of a PSC being the same as that indicated for a facility Contractor.

All of the conduits and conductors associated with the powering and grounding of DCS equipment will be provided (i.e., furnished and installed) by the PSC. All signal and instrumentation network conduits and conductors required between field devices and the PCMs (or PLCs); will be provided by the PSC. All conduits required to route communications cable associated with the DCS data highway and DIN interconnection to various DCS devices; with the LANs; and with the communication system between the pump station and treatment facilities or other pump stations will be provided by the PSC. The DCS data highway and DIN cables will be provided by the PSC. All ancillary conduit needed to interconnect DCS devices will be provided by the PSC. All wire terminations will be performed by the PSC.

The DCS workstations, printers, DCS-UPS equipment, network cables, communication devices, treatment plant-to-pump station communication devices, and telemetry communication modules (which interface the DCS with off-site devices) will be provided by the PSC.

DISTRIBUTED CONTROL SYSTEM

As previously described in this Chapter, a DCS, new or existing, will function as the primary means of performing process monitoring and control at the pump station. In addition, selected pump station support systems such as the gas detection system, fire alarm system, security systems and switchgear/energy monitoring system will be integrated into the DCS to provide a shared and common interface to the operations staff. Although each of the pump station support systems will be designed as a stand-alone system to preserve its integrity, critical informational content related to each support system will be integrated into a global database at the DCS. The PCM or PLC at each pump station will support communications with a Central Operations Management Center (COMC) which will have access to each pump station's global database over the DIN. Pump stations that feed treatment facilities will generally use a fiber optic communications cable buried with the pipeline to communicate with the DCS at the treatment facility.

The DCS will consist of the following primary elements:

1. Either Process Control Modules (PCMs) or a Programmable Logic Controller (PLC) which contains all of the control logic required to monitor and control its associated process. PUD will select a PCM or a PLC for use as the primary controller, based on the size of the pump station, whether it is attended or unattended, and other factors. In general, a PCM will be used at larger, attended stations where there are WSs, and a PLC will be used at smaller and unattended stations. However if a large or attended pump station has an existing PLC of recent design, with MODBUS communications capabilities, it may be used in lieu of a PCM. PLCs, where used as the primary control device, shall be redundant, with automatic bumpless failover.

2. DCS Workstations (WSs), provided at larger and attended pump stations, will serve as the operation's staff "window" into the process, enabling the pump station staff to monitor, interrogate, manipulate, and document pump station processes. The DCS workstation will

use the standard DCS operator interface software. Non-standard PC-based SCADA or operator interface software will not be used. WSs and printers, when provided, will be located in the Operations Control Room (OCR). At pump stations without WSs, the same functions will be performed at the COMC.

3. An Operations Control Room (OCR), located where the pump station's administrative/operation staff functions are accomplished. The OCR will integrate process control and facility administration functions by housing DCS workstations (where provided), printers and all support system interfaces. Additionally, the OCR will house network communication equipment, treatment plant-to-pump station communication devices, and file servers to support the interfaces with support systems.

4. At pump stations with PCMs and WSs, a redundant fiber optic based DCS data highway which links together all PCMs and WSs with all other DCS devices will be used.

5. Communication modules (CMs) will be used to support treatment plant-to-pump station communications over a District Information Network (DIN). At PLC-only pump stations that do not have a local workstation, and where fiber optic is not available, communications to the COMC may be over low-speed media (less than 19,200 bps), using spread-spectrum radio or leased telephone lines. Use of a local WS in the pump station will require a high-speed link, leased T-1 or fiber optic.

6. Low-speed communications between a PLC and external systems shall use the MODBUS RTU protocol, with the PLC operating as the "slave device and a PCM at COMC operating as the "master".

7. Local Maintenance Management System workstations at pump stations will communicate via T-1 leased lines over SANNET.

8. Uninterruptible power supplies (UPSs) providing at least 4 hours of backup power shall be used for all DCS and PLC equipment.

INSTRUMENTATION EQUIPMENT

As stated previously, I&C devices will be industrial grade, with specific emphasis placed upon the devices applicability to wastewater and solids handling applications. As a minimum, all work and equipment will conform to the I&C Standards listed in Table D6-4.

Guidelines for instrumentation equipment have been presented in Tables D6.5 and D6.6. This section highlights the use of equipment for pump stations. Table D6-7 lists recommended instruments for pump stations. The information in this table shall be used as a guide to preferred instrumentation.

Table D6-6 summarizes optional methods of making common measurements. This table shall be used as a general guide to be used when the method listed in Table D6-5 is not applicable.

Engineering judgment must be applied in the selection of instruments. This table does not cover all types of measurements that may be required.

The use of control panels in pump stations will be avoided to facilitate the informational and control content of the DCS. All vendor logic will be configured in the DCS. Field control and monitoring stations will be limited to a clustering of controls to facilitate manual intervention. PCMs and instruments will be designed to accommodate all known immediate loads. Future loads will be allocated to future PCMs and control panels. The PS Design Consultant shall allocate all required space and resources needed to support the installation of immediate and future PCMs. In those instances where future requirements are associated with devices being monitored or controlled by a PCM which is servicing current requirements, these devices will be sized using both current and future control requirements.

Table D6-7
INSTRUMENTATION APPLICATION

Application	Instrument Type
Raw wastewater wet well level	Submersible pressure cell
Pump station flow	Parshall flume, if open channel; or magnetic flow meter on pump discharge
Bar screen differential level	Sonic, differential pressure (d/p) Cell
Flood level	Float switch
Pressure	Diaphragm pressure transmitter
Progressive cavity pump protection	Annular ring pressure sensor on discharge with switch to trip pump on high discharge pressure; pipeline level monitor on suction to trip pump on dry suction. All trip logic and required timers will be hardwired.
Centrifugal pump protection	Pressure switches on the suction and discharge with hardwired timer and control to trip pump upon detection of low suction pressure, high discharge pressure, and low discharge pressure. For pumps in self-cleaning wet wells, provide a local manual bypass of the low suction pressure trip on the pump control panel.
Pump seal water flow	Rotameter (less than one-inch diameter)